

Capturing research landscape and foci of mathematical creativity research (1994-2024)

Tan Jia Wen, Chin Huan

School of Educational Studies, Universiti Sains Malaysia, Georgetown, Malaysia

Article Info

Article history:

Received Jul 26, 2024

Revised Mar 13, 2025

Accepted Mar 19, 2025

Keywords:

Bibliometric analysis
Mathematical creativity
Research domain
Research landscape
Research trend

ABSTRACT

Mathematical creativity is one of the most fascinating research topics in mathematics education. Following preferred reporting items for systematic reviews and meta-analysis (PRISMA) data retrieval protocol, a total of 235 related publications published from 1994 to 2004 were retrieved from Scopus database. By using Microsoft Excel and VOSviewer, bibliometric analysis was performed to comprehensively capture the research trends in the field of mathematical creativity. The results revealed that the publication and citation trends have been rising over time. The publications were dispersed throughout the five continents. The United States is the most prolific and influential nation, with the greatest number of publications, g-index and h-index. Eight research foci have been identified, namely: i) student mathematical creativity and their achievement; ii) assessment of students' mathematical creativity in geometry problem solving; iii) eliciting mathematical creativity; iv) mathematical creativity process; v) assessing of convergent and divergent thinking of gifted students; vi) pre-service teacher mathematical creativity in problem posing and with the aid of technology; vii) mathematical creativity tasks; and viii) mathematical creativity in early childhood. Overall, the findings of this bibliometric analysis are expected to guide researchers in understanding the research pattern over time. This study also provides direction for future research on mathematical creativity.

This is an open access article under the [CC BY-SA](#) license.



Corresponding Author:

Chin Huan
School of Educational Studies, Universiti Sains Malaysia
11800, USM, Georgetown, Penang, Malaysia
Email: chinhuan@usm.my

1. INTRODUCTION

In the era of rapid technological advancement, mathematical creativity has gained increased attention in mathematics education [1]. Previously, creativity was associated only with the arts and literature, but these days, creativity is meaningfully integrated into science, technology, engineering, and mathematics (STEM) subjects, particularly mathematics. Mathematical creativity has emerged as the prerequisite for mathematical learning as it is essential for problem-solving and idea generation [2]. Mathematical creativity can be understood as the ability to solve problems from different perspectives by generating multiple novel solutions [2]. At the school level, mathematical creativity is important for solving non-routine problem-solving [3]. Students need to generate new ideas or multiple solutions to solve problems [4] when dealing with mathematical problem-solving. Hence, mathematical creativity guides students to view and analyse problems through different approaches, relate the problems with suitable mathematical concepts, and select the best way to solve unconventional problems [3]. Therefore, mathematical creativity is inextricably linked to problem-solving [2], [3] and is essential to help students make sense of mathematics and apply

mathematics meaningfully in everyday life [1]. As a result, mathematical creativity has been incorporated into the mathematics curriculum since primary education.

In recent decades, fostering mathematical creativity in education has attracted growing interest, and the research on mathematical creativity is growing [5]. In view of the research on mathematical creativity, numerous facets and underlying theoretical assumptions on mathematical creativity have been studied [5]. For this reason, researchers in mathematics education strats to sort and map previous studies to identify the research gap [5] by conducting systematic literature review (SLR) and meta-analysis (MA). The SLR involves fewer past studies for review [6], and provides a comprehensive summary of the existing literature in past studies on narrow and specific research questions [7]. To understand the concept of mathematical creativity, a SLR was performed to depict the five predominant notions of creativity identified in past research from 2006 to 2019 [5]. On the other hands, MA handles larger volumes of past literature and summarising the empirical evidence by analysing the relationship between variables in past studies [7]. Several researchers have carried out a MA of the literature pertaining to mathematical creativity to investigate the relationship between mathematics achievement and mathematical creativity [8], and analyse the effectiveness of using problem-based learning on Indonesian students' creative mathematical thinking [9].

Notably, SLR and MA are usually focused on a smaller, curated selection of studies due to the practical constraint to provide deep insights into specific research questions or interventions. Thus, it cannot be used for research trend identification. Due to the broad-spanning and heterogeneous research on mathematical creativity, it is crucial for researchers to comprehend and have a deep understanding of research on mathematical creativity for planning future research. With this regards, bibliometric analysis could be used to discover the research trend becuse large volumes of literature and large quantities of bibliometric data can be handled and summarised by bibliometric analysis [7]. Specifically, the bibliometric analysis examines publication patterns, authorship trends, citation networks, and research impact within a body of literature in past studies, whereby the publication and citation trends indicate research growth, whereas the geographical distribution of publications identifies the research gaps [10]. Hence, bibliometric analysis is a more effective method to identify knowledge gaps and present emerging research trends in mathematical creativity.

In the past, bibliometric analysis has been conducted to determine the most most prolific authors and journals and thematic evolutions from 2002 to 2022 [11]. In contrast to the findings of Saefudin *et al.* [11], this study aims to depict the research patterns and trends of mathematical creativity from 1994 to 2024 through bibliometric analysis, which involves a more inclusive database. Furthermore, a keyword co-occurrence analysis will be conducted in this study to identify the research foci in mathematical creativity, which will help to determine the research gaps and determine the direction of future research. Although bibliometric reviews in education have increased in recent years [12], [13], bibliometric analysis on mathematical creativity is still sparked, and there is a lack of study on identifying research foci in mathematical creativity. Therefore, this study is conducted to profile the research landscape on mathematical creativity from 1994 to 2024 and highlight the research foci in mathematical creativity, which will help to determine the research gaps and the direction of future research. Specifically, the research questions addressed in this study are as:

- What is the current publication trend of research related to mathematical creativity?
- What is the geographical distribution of the publication related to mathematical creativity?
- What are the research foci on mathematical creativity?

2. METHOD

2.1. Data collection and retrieval

The document search and refinement process adhered to the preferred reporting items for systematic reviews and meta-analysis (PRISMA) statement, which consisted of four stages: identification, screening, eligibility, and inclusion [14]. This study used the Scopus database to conduct the bibliometric analysis, where the data related to “mathematical creativity” were extracted from the Scopus. This study started with the search for relevant publications. Before the search, the commonly presented keywords for “mathematical creativity” were identified, such as ‘mathematical creativity’ and ‘mathematics creativity’. The search scope was restricted to works published from 1994 until 2024. In addition, the search scope was limited by subject area for better document search efficiency. In this context, the search focused on ‘mathematics’ and ‘education’ as mathematics creativity is in the field of mathematics and education is in the field of social science, whereby only publications related to “mathematical creativity” and “mathematics creativity” would be shortlisted. In this stage, 1085 publications were identified through three search strings, as shown in Figure 1. Since there were 187 duplicates, 898 papers were assessed for screening after eliminating the duplicates. During the screening process, the researchers manually evaluated the publications' titles and

abstracts to determine those that met the inclusion requirement, which focused on mathematical creativity. After being screened, 235 publications were exported in “comma-separated value (CSV)” format and “research information systems (RIS)” format. These files would be included in the bibliometric analysis.

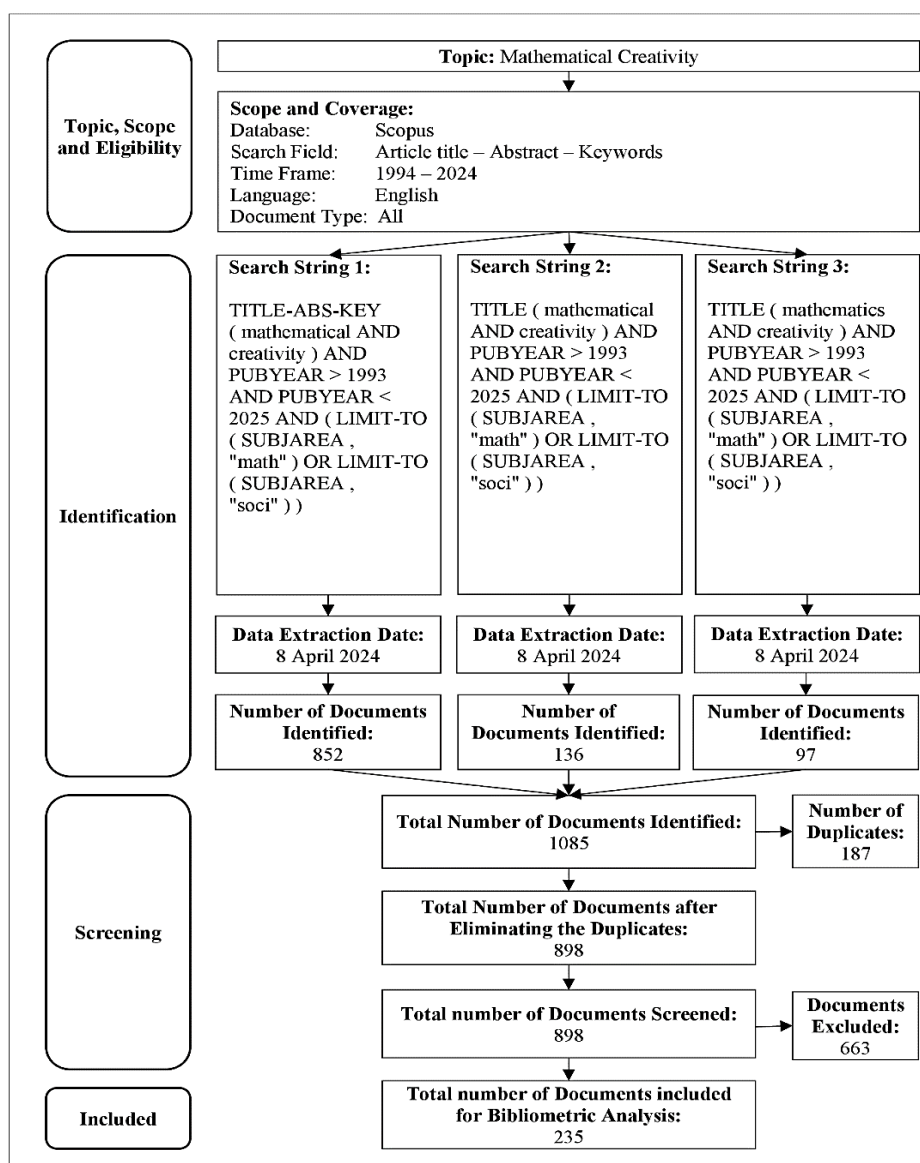


Figure 1. Data collection process

2.2. Data analysis

A descriptive analysis of the bibliometric data retrieved from the Scopus database was carried out to identify the current trend in publications on mathematical creativity. With the aid of Microsoft Excel, graphs showing the total number of publications and the cumulative publications for every year were created. To examine the citation trend of publications related to mathematical creativity, the data retrieved from Scopus was first sorted by year. Then, a global map showing the publication's distribution was created with the aid of Microsoft Excel to track the global distribution of the publication. In addition, average citation per publication (C/P), average citation per cited publication (C/CP), g-index, and h-index for each country were calculated using Microsoft Excel and Harzing's Publish or Perish. Besides, the network visualization and overlay visualization map that displayed the pattern of cooperation across the countries were then created using the VOSviewer. The keywords co-occurrence analysis was performed to discover the research foci on mathematical creativity. In this step, the author's keywords were extracted from the database, and then data pre-processing was carried out before conducting keyword co-occurrence analysis. During the data

pre-processing, the keywords appeared as spelling variants (e.g., ‘creativity’ and ‘creativity’) and synonyms (e.g., ‘mathematical creativity’ and ‘creative mathematics thinking ability’) were standardized. Once the data pre-processing was completed, the keyword co-occurrence network was generated through the VOSviewer, and the keywords in the network that clustered together could be used to identify the research’s foci.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Publication trend

From 1994 to 2024, a total of 235 publications were produced. Most were journal articles (73.28%), followed by book chapters (12.50%), conference papers (8.62%), review articles (3.45%), conference reviews (1.29%) and books (0.86%). The annual publications from 1994 to 2024 were displayed as a bar graph in Figure 2. The year with the most publications throughout this period was 2022, with a total of 33 publications, followed by the year 2023, with a total of 25 publications. A significant increase in publications was observed in 2009, 2013, and 2022. Prior to 2009, there were at most six publications yearly. Compared with prior years, 2009 (n=16) witnessed over double the number of publications (n=16). The growth pattern of the publications was represented on a cumulative frequency graph, as displayed in Figure 2. With a steeper slope from 2009 to 2024 than from 1994 to 2008, the upwardly concave curve suggests an increasing publication tendency over time. The growth pattern indicated a sharp increase in research on mathematical creativity since 2009.

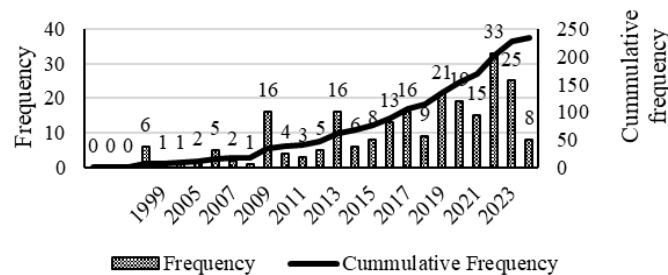


Figure 2. Publication from 1994 to 2024

3.1.2. Geographical distribution of the publications

The publications on mathematical creativity distributed across 52 countries from several continents were stained with colours of varying intensities, including North America (5), Asia (17), Europe (23), Oceania (1), and South America (3). As shown in Table 1, there were 5 countries with at least 10 publications on mathematical creativity. These country is located in North America (United States), Asia (Israel and Indonesia) and Europe (Turkey and the United Kingdom). These 5 countries contributed over half of the total publications. In addition, these 5 countries recorded a high citation rate. Among the countries included in the dataset, the nation with the most outstanding research impact was the United States (h-index=19 and g-index=38). This record implied that out of the 49 cited publications in the United States, at least 19 had received at least 19 citations. Furthermore, the United States had at least 38 cited publications, which added up to a minimum of 1,444 (382) total citation counts. This was followed by Israel with an h-index of 14 and a g-index of 28. Moreover, the Netherlands recorded a total of 6 publications and 6 cited publications, with an h-index of 6 and a g-index of 6. The data shows that each of the 6 papers published in the Netherlands received a minimum of 6 citations.

Table 1. Countries with more than 10 publications

Country	TP (%)	NCP	TC	C/P	C/CP	h	g
United States	59 (25.11%)	49	1469	24.90	29.98	19	38
Israel	36 (15.32%)	28	785	21.81	28.04	14	28
Indonesia	20 (8.51%)	13	201	10.05	15.46	7	13
Turkey	11 (4.68%)	8	55	5.00	6.88	5	7
United Kingdom	11 (4.68%)	8	224	20.36	28.00	5	8

Notes: TP–total number of publications; NCP–number of cited publications; TC–total citations; C/P–average citations per publication; C/CP–average citations per cited publication; h–h-index; and g–g-index.

3.1.3. Research foci

To identify the research foci of mathematical creativity, the keyword co-occurrence analysis was run by using VOSviewer. The analysis included 28 keywords that surpassed the co-occurrence threshold of three. Based on the keyword co-occurrence network shown in Figure 3, the nodes represented the keywords, whilst the edges represented the co-occurrence of the keywords. From the network, the largest node was mathematical creativity, followed by problem-solving, problem-posing, and mathematics, with almost equal-sized nodes. Regarding the edges, the keyword pairs ‘mathematical creativity and problem solving’, ‘mathematical and problem posing’, as well as ‘mathematical creativity and mathematics’ showed relatively thick edges. This scenario indicated a significant correlation between them [15]. As illustrated in Figure 3, the 28 keywords were categorised into clusters, each represented by a distinct colour and referring to a research focus. In this context, the red cluster was recorded as the largest cluster with six keywords. This cluster reflected the research focus on ‘student mathematical creativity and achievement’. This was followed by the green and blue clusters, each with five keywords. In the green cluster, the node sizes of ‘problem-solving’ and ‘mathematics’ were larger than other cluster nodes. Thus, these keywords reflected the research focus, ‘assessment of students’ mathematical creativity in geometry problem-solving.

The blue cluster comprised five terms, with the node size of ‘mathematical creativity’ being relatively bigger than the other nodes in the cluster. Therefore, this cluster of keywords indicated the specific area of research known as ‘eliciting mathematical creativity’. The next cluster was the yellow cluster with four keywords, in which all the nodes in the cluster had almost the same size. Subsequently, the yellow cluster represented the research emphasis on the ‘mathematical creativity process’. The light blue cluster consisted of three keywords, whereby ‘problem-posing’ was the largest node in this cluster. Therefore, this cluster implied a specific area of research on ‘pre-service teacher mathematical creativity in problem posing’. Moreover, the purple cluster was also comprised of three keywords. The node of ‘gifted education’ was relatively larger than other nodes. Thus, the purple cluster reflected the research focus, ‘assessing convergent and divergent thinking of gifted students’. The smallest clusters in the network were the orange cluster and brown cluster with only one keyword. The orange cluster represented the research focus of ‘mathematical creativity tasks’, whereas the brown cluster represented the research focus of ‘mathematical creativity in early childhood’.

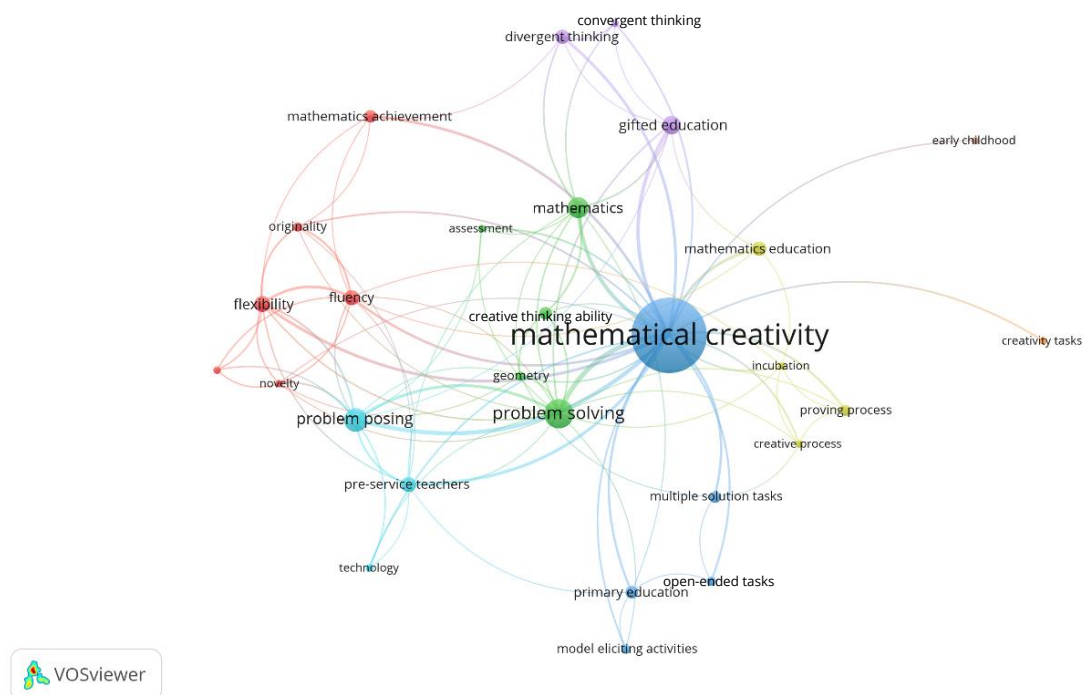


Figure 3. Keyword co-occurrence network (occurrence threshold ≥ 3)

3.2. Discussion

This study is conducted to profile the research landscape on mathematical creativity from 1994 to 2024. While past studies have determined the most prolific authors and journals and thematic evolutions from

2002 to 2022, they have not captured the research foci will help to determine the research gaps and future research direction. The findings of this study are discussed in the following sections.

3.2.1. Publication trend

The findings reveal a rise in the quantity of publications related to mathematical creativity. This finding is consistent with the past study done by Saefudin *et al.* [11], which indicated a significant growth in the quantity of academic publications on mathematical creativity between 2002 and 2022. According to Joklitschke *et al.* [5], mathematical creativity has gained increased interest among researchers, and mathematical creativity has been seen as one of the research priorities in the field of mathematics. In fact, mathematical creativity is crucial for solving non-routine problems and coming up with genuine ideas [16]. In addition, mathematical creativity allows students to make sense of mathematics and apply it meaningfully [1]. Furthermore, the OECD [17] revealed that students with sophisticated mathematical creativity would be able to critically analyse, refine, and acquire concepts that lead to novel and valuable solutions. As a result, the research work related to mathematical creativity has increased over the past two decades.

This study witnessed a substantial surge in the quantity of publications in 2009. The rapid growth in research in 2009 might be due to the effort to address the unsatisfactory mathematics performance in Programme for International Student Assessment (PISA) 2006. As OECD [18] recorded, only 32.5% of students can manipulate various mathematics representations to solve problems related to real-life contexts. Mathematical creativity is a crucial component in problem-solving [19] because mathematical creativity is the ability to view problems in various ways, generate different ideas, and choose the best ways to solve unconventional mathematical problems [20]. Hence, the weak problem-solving skills shown from the unsatisfactory PISA results highlighted a need to study students' mathematical creativity.

In addition, there was a surge of publications in 2009 due to the publication of the book entitled "Creativity in mathematics and the education of gifted students" [21]. 12 out of 16 of the publications in the year 2009 were the book chapters of this book. In 2013 and 2022, two thematic issues focused on mathematical creativity were published in the journal ZDM-Mathematics Education, which led to increased publications. Nearly half (7 out of 16) of the publications recorded in 2013 were articles published in the issue of 'Creativity and Mathematics Education'. Meanwhile, 7 out of 34 publications in 2022 were articles published in the 'Empirical Research on Mathematical Creativity-State-of-the-art' issue.

3.2.2. Geographical distribution of the publications

The United States, Israel, Indonesia, Turkey, and the United Kingdom were the five most productive countries in publishing literature on mathematical creativity. The United States was documented as the most prolific nation among these countries. It was the major contributor to literature related to mathematical creativity, with the greater total number of publications, h-index, and g-index. This finding aligns with the results obtained by Saefudin *et al.* [11], who reported that the United States has historically been the most productive and prominent nation in terms of publications related to mathematical creativity over the last two decades. In fact, the publications published by the most productive countries significantly influence the field of mathematical creativity research. For instance, Bicer *et al.* [8] from the United States conducted a SLR on the instructional practices to foster students' mathematical creativity, and the findings had an essential influence on the development of research on mathematical creativity, particularly those related to learning practices. In addition, one of the significant Israeli publications is Leikin [21], which emphasized the eliciting of mathematical creativity through multiple-solution tasks, which served as the cornerstone for the growth of research in mathematical creativity.

3.2.3. Research foci

The most prominent focus in mathematical creativity is student mathematical creativity and achievement. Since mathematical creativity is the ability to conceive a novel yet mathematically correct solution to mathematics problems through different perspectives [22], mastery of mathematical concepts and skills is crucial for developing mathematical creativity. Therefore, research study on the correlation between mathematical creativity and mathematics achievement gained interest in the research community [23]–[26]. In most empirical research studies, mathematical creativity is usually characterised by three main constructs: fluency, flexibility, and originality [2], [27], [28].

The second focus on mathematical creativity is an assessment of student mathematical creativity in geometry problem-solving. In fact, mathematical creativity and problem-solving are closely related, as Laycock [20] defines mathematical creativity as the ability to view and analyse problems from different perspectives, conceive various ideas, and choose the best way to solve the problem. In past studies, the most popular topic used to assess students' mathematical creativity is geometry [2], [3], [29], [30]. When dealing with mathematics problems related to geometry, students need to make deductions based on the geometric

properties of the shapes and think flexibly to relate the geometric shapes to appropriate formulas instead of merely applying formulas to solve the problem [31], [32]. Hence, students can elicit their mathematical creativity when solving a geometry-related problem.

The next focus in mathematical creativity is eliciting mathematical creativity. To assess mathematical creativity, several types of tasks can be used to elicit mathematical creativity, the commonly used tasks are open-ended tasks [3], [23], [33], multiple solution tasks [25], [34]–[36] and problem-posing tasks [27], [37]. Open-ended tasks with the existence of multiple answers [33] encourage an individual to engage in innovative thinking and generate distinctive solutions. When dealing with multiple solution tasks, presenting problems with multiple solutions [35] encourages individuals to approach the problem from different perspectives and consider various methods. On the other hand, problem-posing tasks that require an individual to formulate new questions or problems for a given problem [38] empower individuals to think creatively and imaginatively [39] and push the boundaries of traditional problem-solving approaches.

Moreover, the mathematical creativity process is also one of the specific research foci in mathematical creativity. Hadamard [40] proposed a well-known model of the creative process in mathematics that defines mathematical creativity as the process of four sequential stages: preparation, incubation, illumination, and verification. Hadamard's model [40] highlights the importance of different cognitive processes and stages that contribute to creative problem-solving and thus has been influential in understanding how creativity unfolds in mathematics.

Apart from that, assessing the convergent and divergent thinking of gifted students is also one of the research foci within the research community. In fact, Guilford [41] distinguished between convergent thinking, which is concerned with identifying a solitary proper answer, and divergent thinking, which prioritises creating multiple solutions and ideas. Also, mathematical creativity is considered as a combination of convergent and divergent thinking [42] where the ability to think divergently can lead to novel insights and creative solutions to mathematical problems.

The following research focus is on pre-service teachers' mathematical creativity in problem-posing and with the aid of technology. In the era of technological advancement, technology enables an individual to observe mathematical situations actively and explore them, leading to enhanced flexibility in problem-solving strategies and originality in problem-posing [43]. By nurturing creativity in pre-service teachers, adopting creative teaching practices that leverage technology can enhance students' mathematical creativity.

The last two foci in mathematical creativity are mathematical creativity tasks and mathematical creativity in early childhood. Since mathematical creativity is usually characterised by fluency, flexibility, and originality, mathematical creativity tasks are expected to be able to reflect these three constructs. Thus, due to the effort of fostering mathematical creativity, studying the effectiveness of creativity tasks is one of the current research foci. Indeed, creative elements are inseparable from children's mathematics learning [44] as they help children make sense of mathematics and present novel ideas and various solutions to mathematics problems [3]. Understanding mathematical creativity in early childhood sheds light on students' mathematical development.

4. CONCLUSION

Bibliometric analysis allows researchers to visualize the mathematical creativity research trends and identify the major foci within mathematical creativity. The trend of publications on mathematical creativity has been gradually increasing, indicating that future years will witness continuous growth in this research field. Notably, the publications of mathematical creativity are widely dispersed geographically and significantly influence the field of mathematics education. The research domains are revealed through the scientific mapping of bibliographic data. This includes: i) student mathematical creativity and their achievement; ii) assessment of student mathematical creativity in geometry problem solving; iii) eliciting mathematical creativity; iv) mathematical creativity process; v) assessing of convergent and divergent thinking of gifted students; vi) pre-service teacher mathematical creativity in problem-posing and with the aid of technology; vii) mathematical creativity tasks; and viii) mathematical creativity in early childhood. The findings of this study are expected to shed light on the research landscapes on mathematical creativity. Understanding trends helps researchers prioritize research efforts and focus on areas with high potential for advancement. Furthermore, bibliometric analysis in mathematical creativity serves as a roadmap for future research, especially for young researchers. The researchers urged to focus on researching mathematical creativity, as the findings on publication growth indicate that mathematical creativity research will remain the trending topic in mathematics education.

Notably, this study has several limitations. Firstly, the data for this bibliometric analysis consisted solely of the Scopus database, and some publications might have yet to be included. Secondly, the documents published after the retrieval date, 8 April 2024, were not considered. Thirdly, this bibliometric analysis study is restricted to the analysis of the author's keyword without including the entire text, so it is conceivable that

the research foci differ. As a result of the recent surge of relevant literature, the findings of this study might contain a minor error and should be evaluated cautiously. Future research on bibliometric analysis on mathematical creativity is recommended to broaden the scope of the data by incorporating additional databases and including the most recent literature.

FUNDING INFORMATION

This work was supported by a Universiti Sains Malaysia, short-term grant with project no: 304/PGURU/6315754

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Tan Jia Wen	✓	✓	✓		✓	✓			✓		✓			
Chin Huan	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓

C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare that are relevant to the content of this article.

ETHICAL APPROVAL

This study did not involve human participants or personal data and was based solely on publicly available literature. Therefore, ethical approval was not required.

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

REFERENCES

- [1] M. H. M. Hafizi and N. Kamarudin, "Creativity in mathematics: Malaysian perspective," *Universal Journal of Educational Research*, vol. 8, no. 3C, pp. 77–84, Mar. 2020, doi: 10.13189/ujer.2020.081609.
- [2] S. D. A. Permatasari, Budiyo, and H. Pratiwi, "Does gender affect the mathematics creativity of junior high school students?," *Journal of Physics: Conference Series*, vol. 1613, no. 1, p. 012036, Aug. 2020, doi: 10.1088/1742-6596/1613/1/012036.
- [3] C. Sinniah, A. H. Abdullah, and S. Osman, "Preliminary study to enhance mathematical creativity in non-routine mathematics problem solving among primary school students," *Journal of Positive School Psychology*, vol. 6, no. 6, pp. 3676–3686, 2022.
- [4] A. Bicer, "A systematic literature review: discipline-specific and general instructional practices fostering the mathematical creativity of students," *International Journal of Education in Mathematics, Science and Technology*, vol. 9, no. 2, pp. 252–281, Mar. 2021, doi: 10.46328/ijemst.1254.
- [5] J. Joklitschke, B. Rott, and M. Schindler, "Notions of creativity in mathematics education research: a systematic literature review," *International Journal of Science and Mathematics Education*, vol. 20, no. 6, pp. 1161–1181, Aug. 2022, doi: 10.1007/s10763-021-10192-z.
- [6] H. Snyder, "Literature review as a research methodology: an overview and guidelines," *Journal of Business Research*, vol. 104, pp. 333–339, Nov. 2019, doi: 10.1016/j.jbusres.2019.07.039.
- [7] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: an overview and guidelines," *Journal of Business Research*, vol. 133, pp. 285–296, Sep. 2021, doi: 10.1016/j.jbusres.2021.04.070.
- [8] A. Bicer, S. Chamberlin, and C. Perihan, "A meta-analysis of the relationship between mathematics achievement and creativity," *The Journal of Creative Behavior*, vol. 55, no. 3, pp. 569–590, Sep. 2021, doi: 10.1002/jocb.474.
- [9] Y. Yunita, D. Juandi, M. Tamur, A. M. G. Adem, and J. Pereira, "A meta-analysis of the effects of problem-based learning on students' creative thinking in mathematics," *Beta: Jurnal Tadris Matematika*, vol. 13, no. 2, pp. 104–116, Nov. 2020, doi: 10.20414/betajtm.v13i2.380.

- [10] M. Suseelan, C. M. Chew, and H. Chin, "Research on mathematics problem solving in elementary education conducted from 1969 to 2021: a bibliometric review," *International Journal of Education in Mathematics, Science and Technology*, vol. 10, no. 4, pp. 1003–1029, Aug. 2022, doi: 10.46328/ijemst.2198.
- [11] A. A. Saefudin, A. Wijaya, and S. I. A. Dwiningrum, "Mapping research trends in mathematical creativity in mathematical instructional practices: A bibliometric analysis," *Journal of Pedagogical Research*, vol. 7, no. 4, pp. 439–458, Sep. 2023, doi: 10.33902/JPR.202322691.
- [12] A. Özdemir, A. Tekin, and Y. Saraçoğlu, "Bibliometric analysis of research on digital transformation and education," *Journal of Educational Technology and Online Learning*, vol. 6, no. 4, pp. 1078–1095, Dec. 2023, doi: 10.31681/jetol.1331297.
- [13] S. Bilgic and M. Baloglu, "A bibliometric analysis of research on giftedness and mathematics," *International Journal of Mathematical Education in Science and Technology*, vol. 56, no. 3, pp. 382–398, Mar. 2025, doi: 10.1080/0020739X.2023.2236611.
- [14] D. Moher, A. Liberati, J. Tetzlaff, and D. G. Altman, "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement," *International Journal of Surgery*, vol. 8, no. 5, pp. 336–341, 2010, doi: 10.1016/j.ijsu.2010.02.007.
- [15] X. Chen, J. Chen, D. Wu, Y. Xie, and J. Li, "Mapping the research trends by co-word analysis based on keywords from funded project," *Procedia Computer Science*, vol. 91, pp. 547–555, 2016, doi: 10.1016/j.procs.2016.07.140.
- [16] L. L. Hadar and M. Tirosh, "Creative thinking in mathematics curriculum: an analytic framework," *Thinking Skills and Creativity*, vol. 33, p. 100585, Sep. 2019, doi: 10.1016/j.tsc.2019.100585.
- [17] OECD, *Draft framework for the assessment of creative thinking in PISA 2021*. Paris: OECD Publishing, 2019.
- [18] OECD, *PISA 2006: science competencies for tomorrow's world executive summary*. Paris: OECD Publishing, 2007.
- [19] J. A. Plucker, R. A. Beghetto, and G. T. Dow, "Why isn't creativity more important to educational psychologists? potentials, pitfalls, and future directions in creativity research," *Educational Psychologist*, vol. 39, no. 2, pp. 83–96, Jun. 2004, doi: 10.1207/s15326985ep3902_1.
- [20] M. Laycock, "Creative mathematics at Nueva," *The Arithmetic Teacher*, vol. 17, no. 4, pp. 325–328, Apr. 1970, doi: 10.5951/AT.17.4.0325.
- [21] R. Leikin, "Exploring mathematical creativity using multiple solution tasks," in *Creativity in Mathematics and the Education of Gifted Students*, R. Leikin, A. Berman, and B. Koichu, Eds., Rotterdam: BRILL, 2009, pp. 129–145, doi: 10.1163/9789087909352_010.
- [22] B. Sriraman, "Are giftedness and creativity synonyms in mathematics?," *Journal of Secondary Gifted Education*, vol. 17, no. 1, pp. 20–36, Nov. 2005, doi: 10.4219/jsge-2005-389.
- [23] N. H. A. Hamid and N. Kamarudin, "Assessing students' mathematics achievement and mathematical creativity using mathematical creative approach: a quasi-experimental research," *Asian Journal of University Education*, vol. 17, no. 2, pp. 100–112, Jun. 2021, doi: 10.24191/ajue.v17i2.13399.
- [24] S. Akgül and N. G. Kahveci, "Developing a model to explain the mathematical creativity of gifted students," *European Journal of Education Studies*, vol. 3, no. 8, pp. 125–147, 2017.
- [25] D. Assmus and T. Fritzlar, "Mathematical creativity and mathematical giftedness in the primary school age range: an interview study on creating figural patterns," *ZDM – Mathematics Education*, vol. 54, no. 1, pp. 113–131, Apr. 2022, doi: 10.1007/s11858-022-01328-8.
- [26] A. L. Tubb, D. H. Cropley, R. L. Marrone, T. Patston, and J. C. Kaufman, "The development of mathematical creativity across high school: Increasing, decreasing, or both?," *Thinking Skills and Creativity*, vol. 35, p. 100634, Mar. 2020, doi: 10.1016/j.tsc.2020.100634.
- [27] S. Akgül and N. G. Kahveci, "A study on the development of a mathematics creativity scale," *Eurasian Journal of Educational Research*, vol. 16, no. 62, pp. 57–76, Feb. 2016, doi: 10.14689/ejer.2016.62.5.
- [28] R. Leikin and M. Lev, "Multiple solution tasks as a magnifying glass for observation of mathematical creativity," in *Proceedings of the 31st international conference for the psychology of mathematics education*, 2007, pp. 161–168.
- [29] N. R. Aini, S. Susanto, E. Yudianto, H. T. Wijaya, and E. Cahyanita, "The development of geometry test to analyze students' creative thinking skills in the area of square formula derivation," *Journal of Physics: Conference Series*, vol. 1836, no. 1, p. 012050, Mar. 2021, doi: 10.1088/1742-6596/1836/1/012050.
- [30] S. Rahayuningsih, Sirajuddin, and M. Ikram, "Using open-ended problem-solving tests to identify students' mathematical creative thinking ability," *Participatory Educational Research*, vol. 8, no. 3, pp. 285–299, Aug. 2021, doi: 10.17275/per.21.66.8.3.
- [31] M. Suseelan, C. M. Chew, and H. Chin, "School-type difference among rural grade four malaysian students' performance in solving mathematics word problems involving higher order thinking skills," *International Journal of Science and Mathematics Education*, vol. 21, no. 1, pp. 49–69, Jan. 2023, doi: 10.1007/s10763-021-10245-3.
- [32] M. Suseelan et al., "Gender difference of rural grade five students' performance in solving word problems involving measurement formulae and higher-order thinking skills," *Turkish Journal of Computer and Mathematics Education*, vol. 12, no. 6, pp. 5561–5573, 2021.
- [33] E. Levenson, R. Swisa, and M. Tabach, "Evaluating the potential of tasks to occasion mathematical creativity: definitions and measurements," *Research in Mathematics Education*, vol. 20, no. 3, pp. 273–294, Sep. 2018, doi: 10.1080/14794802.2018.1450777.
- [34] R. Leikin, "Evaluating mathematical creativity: the interplay between multiplicity and insight," *Psychological Test and Assessment Modeling*, vol. 55, no. 4, pp. 385–400, 2013.
- [35] I. J. Osakwe et al., "Multiple solution tasks: an approach for enhancing secondary school students' mathematical creativity," *Multicultural Education*, vol. 8, no. 4, pp. 73–84, 2023.
- [36] L. A. M. Rocena and M. N. B. Joaquin, "A comparative investigation of the mathematical creativity of Pilipino and Japanese students," *International Journal of Studies in Education and Science (IJSES)*, vol. 2, no. 1, pp. 59–73, 2021.
- [37] A. Bicer, Y. Lee, C. Perihan, M. M. Capraro, and R. M. Capraro, "Considering mathematical creative self-efficacy with problem posing as a measure of mathematical creativity," *Educational Studies in Mathematics*, vol. 105, no. 3, pp. 457–485, Nov. 2020, doi: 10.1007/s10649-020-09995-8.
- [38] S. Mishra and S. Iyer, "An exploration of problem posing-based activities as an assessment tool and as an instructional strategy," *Research and Practice in Technology Enhanced Learning*, vol. 10, no. 1, p. 5, Dec. 2015, doi: 10.1007/s41039-015-0006-0.
- [39] J. S. Kozłowski, S. A. Chamberlin, and E. Mann, "Factors that influence mathematical creativity," *The Mathematics Enthusiast*, vol. 16, no. 1–3, pp. 505–540, Feb. 2019, doi: 10.54870/1551-3440.1471.
- [40] J. Hadamard, *The psychology of invention in the mathematical field*. New Yor: Dover, 1945.
- [41] J. P. Guilford, "The structure of intellect," *Psychological Bulletin*, vol. 53, no. 4, pp. 267–293, 1956, doi: 10.1037/h0040755.
- [42] J. P. Guilford, "Creativity: yesterday, today and tomorrow," *The Journal of Creative Behavior*, vol. 1, no. 1, pp. 3–14, Jan. 1967, doi: 10.1002/j.2162-6057.1967.tb00002.x.

- [43] W. Daher and A. Anabousy, "Creativity of pre-service teachers in problem posing," *EURASIA Journal of Mathematics, Science and Technology Education*, vol. 14, no. 7, pp. 2929–2945, May 2018, doi: 10.29333/ejmste/90994.
- [44] Y. Shen and C. P. Edwards, "Mathematical creativity for the youngest school children: kindergarten to third grade teachers' interpretations of what it is and how to promote it," *The Mathematics Enthusiast*, vol. 14, no. 1–3, pp. 325–346, Jan. 2017, doi: 10.54870/1551-3440.1401.

BIOGRAPHIES OF AUTHORS



Tan Jia Wen    is a master in School of Educational Studies, Universiti Sains Malaysia. She obtained her bachelor of science with education at the University Sains Malaysia in 2023. Currently, she serves as graduate research assistant in School of Educational Studies, Universiti Sains Malaysia for short term grant with project number 304/PGURU/6315754. She can be contacted at email: jwentan27@gmail.com.



Chin Huan    is a lecturer in School of Educational Studies, Universiti Sains Malaysia. She obtained her PhD (mathematics education) at the University Sains Malaysia in 2021. She continues to do research and publish research articles in both national and international refereed journals in mathematics education. She can be contacted at email: chinhuan@usm.my.